

## Transport with ongoing cardiopulmonary resuscitation may not be futile

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**Background.** Despite it being generally regarded as futile, patients are regularly brought to the emergency department with ongoing cardiopulmonary resuscitation (CPR).

**Methods.** Long-term outcome and its predictors in patients who were transported during ongoing CPR were evaluated in an observational study. Adult patients with non-traumatic cardiac arrest admitted to the Department of Emergency Medicine of a tertiary-care facility after transport with ongoing chest compression were retrospectively analysed. Multivariate analysis of epidemiological variables, treatment, blood gas values on admission, cause of arrest, and location of arrest was performed to find factors that were predictive for favourable long-term outcome (6-month survival, best cerebral performance category 1 or 2).

**Results.** Over 15 yr (1991–2006), a total of 2643 patients were treated after cardiac arrest. Of these, 327 patients received chest compressions during transport and were analysed (out-of-hospital cardiac arrest:  $n=244$ , in-hospital:  $n=83$ ; the remaining 2316 patients were either stabilized before transport or suffered their arrest in our department). Return of spontaneous circulation was achieved in 31% of patients ( $n=102$ ). Of these, 19 (19%) had favourable long-term outcome (6% of total). Independent predictors of good outcome were age, witnessed arrest, amount of epinephrine, and initial shockable rhythm. Among the patients with cardiac origin of arrest, 11 out of 197 patients (6%) survived; pulmonary origin, 4 out of 46 patients (9%); hypothermic arrest, 1 of 10 patients (10%); and intoxications, one out of nine patients (11%).

**Conclusions.** Post-resuscitation care in patients who receive CPR during transport is not futile. Once restoration of spontaneous circulation is established, one out of five patients will have good long-term outcome.

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In cardiac arrest, the continuation of cardiopulmonary resuscitation (CPR) with transport to hospital is generally considered futile, if advanced life support measures fail on the scene.<sup>1–7</sup> Accordingly, the recommendation<sup>8</sup> has been not to transport patients before stabilization with return of spontaneous circulation (ROSC) is achieved. Nevertheless, under certain circumstances, patients are transported to hospital under ongoing CPR and their long-term survival has never been reported in detail. Our present impression is that these patients are chosen with a certain bias (younger, hypothermic, witnessed arrest, and potential reversible cause).

In the present work, we report data of patients transferred to our emergency department and aim to elucidate

factors which identify an increased likelihood of favourable long-term outcome in patients who received CPR during transport.

### Methods

A retrospective cohort study of using data collected at the time of the hospital episode was performed. It was based on a prospective registry of adult patients with cardiac arrest from an urban population who were admitted to the Department of Emergency Medicine at our University Hospital. The use of the registry was approved by the Ethics Committee.

### *Emergency medical system*

Vienna has a population of ~1.6 million, spread over an area of ~400 km<sup>2</sup>. There are 16 physician-staffed ambulances and one rescue helicopter. Cardiac arrests (on the scene and en-route) are the domain of physician-staffed ambulance teams, although the first responders are often regular ambulance teams. In case of an unsuccessful advanced cardiac life support attempt, the resuscitation can be terminated in the field by the emergency physician. Patients need not be transported to the hospital to be pronounced dead. Therefore, virtually all transports during CPR are initiated at the discretion of an emergency physician.

### *Patients, setting*

This cohort study included adult patients with non-traumatic cardiac arrest admitted to the Department of Emergency Medicine at the University Hospital. To be eligible for analysis, patients had to have CPR during transport. This group encompasses both patients with out-of-hospital cardiac arrest and patients resuscitated inside our hospital. The University Hospital of Vienna, a 2200 bed tertiary-care facility has three cardiac arrest teams. Ours mainly covers out-patient clinics, the radiology department, and public areas (hallways, waiting areas, etc.). Our Department of Emergency Medicine has 14 beds, four of which are fully equipped for intensive care. At least four physicians (medical intensivists) and five certified intensive care nurses are on duty at any time of the week. Throughout the period of this study, our department was the only one capable of accepting patients for emergency cardiopulmonary bypass. Open chest heart compression<sup>9</sup> is not a routine intervention for unresuscitable patients in our department. In-hospital post-resuscitation care was equal for all patients, including therapeutic hypothermia when appropriate.

Treatment of patients until ROSC and post-resuscitation care was according to international guidelines and recommendations and was provided by paramedics and emergency medicine physicians. The time of ROSC was defined by the first signs of life (breathing, coughing, and movement), palpable pulses, or a measurable arterial pressure which lasted for 5 min. Neurological outcome before and after the event was evaluated using the cerebral performance categories (CPCs),<sup>10</sup> which are based on the Glasgow overall performance categories and are defined as follows: 1, conscious and alert with normal function or only slight disability; 2, conscious and alert with moderate disability; 3, conscious with severe disability; 4, comatose or in a persistent vegetative state; 5, brain death. The best CPC score ever reached within 6 months after ROSC was used for the analysis.

### *Data collection, definitions*

Age, sex, BMI, time intervals from collapse to first aid ('no flow time'), duration of resuscitation efforts ('low flow time'), initial ECG rhythm, number of defibrillation attempts

and cumulative amount of medications, and location of arrest were documented. Furthermore, the use of pacemaker, thrombolysis, and cardiopulmonary bypass, laboratory values including blood gas, potassium, and glucose obtained immediately after arrival, the cause of arrest as presumed upon arrival, and duration of stay in intensive care or general ward were also recorded in our resuscitation registry. Time intervals were ascertained in every patient by checking and correcting for clock synchronization of the defibrillator. The clocks of the dispatch centre and of the ambulances data terminals are synchronized every day automatically. Time intervals were analysed only in patients with witnessed arrests. No time interval estimates were made in patients with non-witnessed arrests. Cerebral outcome was evaluated routinely at predefined time-points by the members of our research team. Assessors were not blinded to any detail of the history of the patient, but were unaware of the aim of this study. The CPC<sup>10</sup> was used for neurological evaluation. The duration of treatment in the hospital was calculated in days, starting with a minimum of 1 day on admission.

### *Endpoint*

The primary outcome of this analysis was a long-term survival of at least 6 months with no or only moderate neurological deficit (best CPC within 6 months: 1 or 2). Length of hospital stay was measured as a secondary outcome.

### *Statistics*

Continuous data are presented as number and percentage or median and 25–75% interquartile range (IQR). Dichotomous data are presented as number, percentage, and 95% confidence interval (CI) of frequencies. For univariate hypothesis testing, Fisher's exact-test or Mann-Whitney *U*-test was used as appropriate. For proportions, we calculated exact 95% CIs. We used multivariable logistic regression to examine independent predictors for good neurological outcome. If a variable was associated with favourable outcome in the univariate analysis at  $\alpha=0.25$ , it was included into the model. From continuous variables, we generated terciles to examine the assumption of linear effects. We used the likelihood ratio test for departure from linear trend. The likelihood ratio test was also used to examine the contribution of variables to the model. Assuming that the patients having ROSC during transport might differ from those not having ROSC during transport, we tested for interaction of the main effects with a test for heterogeneity. The Hosmer-Lemeshow test was used and indicated a good fit of the final model ( $P=0.99$ ). For all calculations, we used MS Excel 2003 and Stata 8.2 for Windows (Stata Corp., College Station, TX, USA). A two-sided  $P<0.05$  was considered statistically significant.

### **Results**

From 1991 to 2006, a total of 2643 patients were admitted to our department after resuscitation. Among these, 327

**Table 1** Epidemiological characteristics of patients with CPR during transport. Values are median (IQR) unless indicated otherwise (*n*, %). Good long-term survivors means survival >6 months with cerebral performance category 1 or 2. \*CPR, cardiopulmonary resuscitation. †Duration of low flow was documented in patients with ROSC only (not aborted attempts)

	All patients	Favourable outcome	Unfavourable outcome	P-value
Total, <i>n</i> (%)	327 (100)	19 (100)	308 (100)	
Male, <i>n</i> (%)	220 (67)	12 (63)	208 (68)	0.80
Age, yr (IQR)	59 (45–70)	44 (38–54)	60 (47–70)	0.007
Body mass index, kg m <sup>-2</sup> (IQR)	26 (23–29)	27 (23–30)	26 (23–29)	0.89
Witnessed cardiac arrest, <i>n</i> (%)	289 (88)	18 (95)	271 (88)	0.71
Time from collapse to CPR* ('no flow'), min	0 (0–5)	0 (0–3)	0 (0–5)	0.45
Duration of CPR ('low flow'), min	49 (25–70)	47 (28–61)	51 (25–71) <sup>†</sup>	0.53
Bystander CPR yes, <i>n</i> (%)	74 (23)	3 (16)	71 (23)	0.58
Initial shockable rhythm, <i>n</i> (%)	138 (42)	11 (58)	127 (41)	0.14
Total number of shocks given	3 (1–6)	5 (3–6)	3 (1–6)	0.30
Cumulative epinephrine, mg	7 (4–10)	4 (3–6)	7 (4–10)	0.005
Cumulative amiodarone, mg	300 (300–487)	0 (0–0)	300 (300–487)	0.25
Cumulative vasopressin, mg	40 (40–60)	40 (40–60)	40 (40–60)	0.35
Cumulative sodium bicarbonate, mmol	100 (100–100)	100 (100–150)	100 (100–100)	0.33
Cumulative atropine, mg	1.5 (1–3)	1 (1–3)	2 (1–3)	0.93
Thrombolysis, <i>n</i> (%)	23 (7)	3 (16)	20 (7)	0.14
Use of pacemaker, <i>n</i> (%)	10 (3)	1 (5)	9 (3)	0.46
Use of cardiopulmonary bypass, <i>n</i> (%)	21 (6)	2 (11)	19 (6)	0.33
CPR aborted after min	73 (50–101)	n.a.	73 (50–101)	n.a.

patients were transported during resuscitation and were therefore included into our analysis (Table 1) (244 from out-of-hospital, 83 from inside hospital). One hundred and two patients (31%) had ROSC.

Twenty-seven (8%) patients regained consciousness after resuscitation. Nineteen out of 26 ICU survivors (19% of patients with ROSC, 6% of all patients) were discharged from hospital and had favourable long-term outcome.

Survival was not different among those patients who had ROSC during transport and who were admitted in a more or less stable condition ( $n=4/30$ ) as compared with patients who arrived with ongoing chest compressions (13% vs 5%,  $P=0.103$ ).

Median (IQR) length of stay of patients with favourable long-term outcome was 16 (10–22) days in the intensive care unit (ICU) compared with 1 (1–1) day for patients with unfavourable outcome. The length of stay on the general ward was 28 (5–50) days for survivors and 0 (0–0) days for patients with unfavourable long-term outcome ( $P<0.0001$  for both ICU and ward length of stay).

One hundred and five arrests were witnessed by the emergency medical team: 42% and 31% among the survivors and the non-survivors, respectively ( $P=0.32$ ). (See Table 1.)

Metabolic variables on hospital admission are reported in Table 2. Signs of hyperventilation (arterial  $P_{CO_2}<4.7$  kPa) were observed in 1 of 19 (5%) patients with favourable long-term survival and in 47 of 308 (15%) patients with unfavourable outcome. This difference was not statistically significant ( $P=0.75$ ).

The survival rate was not different between in-hospital and out-of-hospital arrests (6% vs 6%,  $P=0.99$ ).

When outcome was stratified by the cause of arrest, we found that the patients with cardiac origin of arrest had a survival rate of 6% (11 of 197 patients), with pulmonary origin 9% (4 of 46), hypothermic arrest of 10% (1 of 10), and intoxications 11% (one of nine patients).

Multivariate analysis revealed the following variables as predictors for unfavourable outcome: age (OR 1.03 yr<sup>-1</sup>, 95% CI 1.001–1.06,  $P=0.046$ ), lactate (OR 1.22 mmol<sup>-1</sup> litre<sup>-1</sup>, 95% CI 1.06–1.41,  $P=0.007$ ), and initial ECG (OR 0.2 if shockable, 95% CI 0.07–0.62,  $P=0.005$ ). The cumulative dose of epinephrine was close to statistical significance (OR 1.2 mg<sup>-1</sup>, 95% CI 0.997–1.45,  $P=0.054$ ). Thrombolysis, pH, base excess,  $P_{aO_2}$ , potassium, blood glucose, arrest inside vs outside hospital, and arrest witnessed by emergency medical service had no contribution. ROSC before admission did not predict survival and had no interaction with the main effects.

**Table 2** Blood gas values on arrival at emergency department. Values indicated are median (IQR). Good long-term survivors means survival >6 months with CPC 1 or 2

	All patients ( <i>n</i> =327)	Favourable outcome ( <i>n</i> =19)	Unfavourable outcome ( <i>n</i> =308)
Arterial $P_{O_2}$ , kPa (IQR)	12.5 (8.3–26.7)	19.7 (12.5–35)	12 (8.1–25.8)
Arterial $P_{CO_2}$ , kPa (IQR)	5.7 (4.9–8.1)	6.8 (6–7.6)	6.4 (48) (4.9–8.2)
pH, mmol litre <sup>-1</sup>	6.98 (6.9–7.1)	7.03 (7–7.2)	6.98 (6.7–7.1)
Base excess, mmol litre <sup>-1</sup>	-18 (-23 to -15)	-16 (-19 to -10)	-19 (-23 to -15)
Serum lactate, mmol litre <sup>-1</sup>	15 (13–19)	12 (8–14)	16 (13–19)
Serum K <sup>+</sup> , mmol litre <sup>-1</sup>	4 (3–5)	3.4 (2.5–4)	4.1 (3.1–5.3)
Serum glucose, mmol litre <sup>-1</sup>	21 (15.5–27)	16.8 (14.2–21)	21.4 (15.8–27.4)

## Discussion

Our patient selection contrasts sharply to earlier reports from emergency medical service systems where all patients who could not be stabilized were transported.<sup>4-6</sup> In Vienna, the EMS responds to ~2400 cardiac arrests per year. In about 600 patients<sup>11</sup> CPR is started, and of these, 97% of patients are either stabilized or declared dead on the scene. Therefore, our study population is highly selected.

The total outcome of 6% in our study population is the highest reported survival rate to date. In one of the first descriptions of transport and CPR by Erhardt and colleagues<sup>12</sup> in 1979, the rate of positive outcome was 3% (11 of 319 patients).

Most non-survivors died either in the emergency department or in the ICU on the day of the arrest. We therefore do not consider it a large burden on our hospital to receive patients under ongoing CPR. Rather, we support the freedom of individual decision by the emergency physician in the field to initiate transport if the situation is deemed appropriate.

Compared with patients with unfavourable outcome, long-term survivors were younger,<sup>13-14</sup> and survivors had a high percentage of witnessed arrests, short no flow time intervals and low percentage of patients with an initially shockable rhythm as compared with those of Van der Hoeven,<sup>2</sup> who found a favourable outcome only in patients with ventricular fibrillation.

Surprisingly, there was only one patient with hypothermia and no patient with drowning as the cause of arrest among our long-term survivors. This is in distinct contrast with much quoted recommendation<sup>8-15</sup> and our own previous perception<sup>16</sup> that these are together with trauma and intoxication victims,<sup>17-18</sup> the classic exception to the rule not to transport patients under ongoing CPR.

In most reports on CPR during transport, EMS systems without out-of-hospital physicians are described. A major contributing difference to the system in our report is the physician's decision to terminate resuscitation efforts, which is not the case in most systems.<sup>1-2, 4-7, 14, 19-21</sup>

The reasons why the emergency physician decided to transport the patient instead of aborting CPR efforts were not documented. Our impression is that it is more of an intuitive decision-making model instead of a rational decision. Psychological pressure may be among these factors. Hick and colleagues<sup>22</sup> found non-medical factors (weather, arrest witnessed by rescue crew, public place) to be a minor contributor in such a scenario. Medical reasons for CPR under transportation (e.g. potentially reversible cause of arrest, etc.) accounted for 28% of the arguments to transport patients under ongoing CPR.

Our results are in accordance with the criteria of the termination of resuscitation (TOR) study,<sup>19-20</sup> although the EMS system in those studies (emergency medical technicians only) was different from ours. The criteria of the TOR study<sup>19</sup> (arrest not witnessed by EMS, no shock

delivered, no ROSC before transport) correctly predicted unfavourable outcome in our study (no false negative prediction). However, not all patients with good outcome fitted into this simple distinction. The authors of the TOR study did not define ROSC. In our registry, we report 'any ROSC' (palpable pulse) and 'sustained ROSC' (palpable pulse >20 min). Therefore, patients may have had a palpable pulse for 1 min, then rearrested thus causing the emergency physician to initiate transport.

Although assuming some effect, we cannot find out what impact the transport itself might have had on outcome.<sup>23</sup> Transporting the patient from the location of arrest to the vehicle may cause a detrimental effect on perfusion because of ineffective CPR in stairways, etc. The group of patients coming from a private apartment/house was markedly lower than the incidence of cardiac arrest in general in such places is: approximately two-thirds to three-quarters of all out-of-hospital cardiac arrests happen at home.<sup>11-21</sup> In our study, this proportion is much lower (29%, 70 out of 242 patients).

One important factor that may comprehensively explain the mismatch of results found in all the studies may be the quality of resuscitation provided during the rescue, with or without transport.<sup>24-25</sup> Out-of-hospital advanced cardiac life support in the hands of too few rescuers may, in fact, shift the priorities from essentials to measures without proven effect.<sup>26</sup> This latter aspect may also explain why in the Schoenenberger study<sup>3</sup> outcome was not worse in the group with out-of-hospital basic life support only as compared with the group who received physician-controlled advanced cardiac life support. Automatic devices delivering chest compressions may have a supporting role here.<sup>27</sup>

## Limitations

As mentioned above, we assume a substantially lower quality of CPR on the way to the ambulance (i.e. on staircases, etc.) than if the patient is immobile (on scene or in the vehicle). Our analysis could therefore not be corrected for this special low (or no) flow interval. It is a further limitation that we did not prospectively ask the transporting physician for the reasons leading to the transport. There may be a selection mechanism which is beyond the known predictors of resuscitation success (ECG rhythm, witnessed arrest, low flow duration, etc.).

## Future research

In a further attempt to elucidate the factors leading to the transport of a resuscitation patient, we have started to interview the transporting physician on admission. However, any variable identified would need to be studied on patients in whom resuscitation was abandoned in the field in order to establish validity. In our hospital, we have no access to these patients or to the responding EMS teams.

## Conclusion

We conclude that the decision of the emergency physician to transport under CPR is justified in selected patients. If a patient is admitted with ongoing chest compressions, further efforts are not futile, and after ROSC long-term outcome is good (19%).

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